

17. CONCLUSIONS AND RECOMMENDATIONS

The City of Indianapolis (City) prepared a Draft Long Term Control Plan (LTCP) in April 2001 to meet state and federal regulations pertaining to the reduction in combined sewer overflows (CSOs), and the improvement of receiving water quality. As part of this overall process, the Fall Creek Evaluation Study was undertaken to evaluate the proposed Fall Creek/White River storage tunnel, flow augmentation strategies and CSO consolidation sewers. This report provides alternatives, considerations, preliminary opinions of probable costs and a preliminary project schedule for the design and construction of the Fall Creek/White River Tunnel and Flow Augmentation System.

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Based on information presented in this report, several conclusions were drawn for important components of the project. These conclusions are as follows:

- ◆ Available literature, boring logs and well information on the regional geology and hydrogeology were reviewed for the project. This provided background information on the topography, soils, bedrock, hydrogeology and public and private wells. However, limited geotechnical and groundwater data were discovered within or near the proposed tunnel corridor.
- ◆ The tunnel is proposed to be constructed in bedrock approximately 210 feet below ground surface (bgs) at the northern end and 260 feet bgs at the southern end using a tunnel boring machine (TBM) for excavation. It was concluded that the main tunnel should be constructed in limestone and dolomitic rock. Geotechnical design considerations and groundwater impacts are the primary risks for the tunneling effort. Therefore, the tunnel invert depth should be revisited and adjusted, as appropriate, following the completion of the geotechnical exploration program.
- ◆ The tunnel volume was evaluated for 95, 97 and 99 percent capture based on CSO outfall flows and tunnel volume data provided by the Indianapolis Clean

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Stream Team (CST) and the City of Indianapolis Department of Public Works (DPW). If the tunnel length is confined to the evaluation area with an approximate maximum distance of 10.5 miles, it would be impractical and cost prohibitive to construct a tunnel for 99 percent capture due to the large finished diameter required (up to 45 feet). It would be feasible to construct the tunnel for 95 or 97 percent capture based on the required smaller finished diameter of 26 to 35 feet. However, the main tunnel should be designed with provisions to expand the length in the future to achieve a 99 percent capture rate. If expanded in the future, the tunnel would require extension by approximately 80,000 and 30,000 linear feet at the same diameter required for 95 and 97 percent capture, respectively.

- ◆ The three routing alternatives evaluated for the tunnel alignment were the West, Central and East Alignments. Based on the consideration of several factors, available data, project costs and decision screening, the West Alignment appears to be the most favorable alternative (see Appendix K, Preliminary Tunnel Alignment, for a detailed drawing of this alignment). The main tunnel associated with the West Alignment would be 50,290 feet long and have a finished diameter of 26 and 33 feet based on 95 and 97 percent capture of CSOs, respectively. Additional information on the West Alignment is presented in Section 3 of this report.
- ◆ To reduce operations and maintenance concerns for the tunnel, it is recommended that the tunnel grade permit minimum flow velocities of 2.5 to 3.5 feet per second (fps). In order to limit the deposition of solids along the tunnel, the preliminary downward slope was determined to be a minimum of 0.1 percent. Since the tunnel will be used primarily for storage, the flow velocity and slope of the tunnel will be dictated mainly by the water level and pumping rate out of the tunnel. The tunnel slope should be revisited and adjusted, as appropriate, following the completion of the geotechnical exploration program and during the detailed design phase.

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- ◆ Three alternatives for the tunnel working shaft site were evaluated and include: Reilly, Southern Avenue, and Bluff Road sites. Based on the consideration of several factors and available data, the Bluff Road site appears to be the most favorable alternative. The working shaft is expected to be 40 to 50 feet in diameter depending on the percent capture selected and the required diameter for the main tunnel. The primary working shaft site requires six or more acres of land to complete the tunnel construction operation. The Bluff Road site property has approximately 20 acres and is for sale by a private owner at the time of this report writing. Additional information on the tunnel working shaft sites is presented in Section 3 of this report.
- ◆ It was determined that at least one intermediate working shaft should be included in the project at a location approximately midway along the tunnel alignment. The intermediate working shaft also would be used as a drop shaft (DS). Drop shaft DS-08 is the preferred location for the West Alignment intermediate working shaft and is located in the Bush Stadium parking lot. This property is owned by the City and is leased to Indiana University-Purdue University Indianapolis (IUPUI) for satellite parking.
- ◆ Two alternatives for the retrieval shaft site were evaluated and include: Sutherland Avenue and Keystone Dam sites. Based on the consideration of several factors and available data, the Sutherland Avenue site appears to be the preferred alternative. The retrieval shaft is expected to be approximately 40 feet in diameter and would be used to remove the TBM. The retrieval shaft site also could serve as a drop shaft location. The Sutherland Avenue site is greater than two acres and currently vacant. Access to the property would require a crossing of the Norfolk and Western Railroad tracks. If this site is selected, the railroad company should be contacted to verify if access can be obtained. Additional information on the tunnel retrieval shaft sites is presented in Section 3 of this report.

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- ◆ A preliminary design and evaluation of the Deep Tunnel Pump Station was completed for dewatering the tunnel. The Deep Tunnel Pump Station should be designed to initially dewater up to 310 million gallons (MG) within a 3-day period with provisions for expansion up to 504 MG in the future. The 310 and 504 MG volumes are equivalent to 97 and 99 percent capture, respectively, of tunnel CSO storage. The Deep Tunnel Pump Station should be constructed in a shaft adjacent to the tunnel's primary working shaft. The primary working shaft should be converted to a screening facility upon completion of the tunnel. Two pump configuration alternatives were evaluated, including single-stage and two-stage pumping. Following a review of the advantages and disadvantages of each configuration, it was concluded that single-stage pumping would offer lower costs and greater reliability and flexibility than two-stage pumping. Additional information on the Deep Tunnel Pump Station is presented in Section 4 of this report.

- ◆ Forty-three combined sewer overflow outfalls were identified along Fall Creek and White River in the project area that require capture and diversion to the tunnel. As requested by the DPW, the consolidation sewers and diversion structures should be sized for 99 percent capture of the CSOs. The CSO outfalls should be consolidated for cost considerations and operations efficiency prior to their connection to the main tunnel. Since modeling data for the White River portions of the project were not available at the time of this study, assumptions were made to determine the 99 percent capture flow rate for the associated CSO outfalls. Controls associated with the consolidation sewers are needed to restrict flows into the tunnel. The passive, active or real-time controls will prevent surcharging above the groundwater table and reduce the likelihood of exfiltration out of the tunnel. Additional information on the consolidation sewers and diversion structures is presented in Section 5 of this report.

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- ◆ It is anticipated that 21 drop shafts will be needed to convey the CSOs to the tunnel for storage. As requested by the DPW, the drop shafts will be sized for 99 percent capture. Drop shafts may be combined with the intermediate and retrieval shafts to reduce project costs and operations and maintenance needs. Additional information on the drop shafts is presented in Section 5 of this report.
- ◆ Connection tunnels are needed to convey CSOs from the drop shafts to the main tunnel for storage. As requested by the DPW, the connection tunnels will be sized for 99 percent capture of the CSOs. Significant design considerations for the connection tunnels include geotechnical and groundwater impacts. Therefore, the depths of the connection tunnels should be revisited and adjusted, as appropriate, following the completion of the geotechnical exploration program. Additional information on the connection tunnels is presented in Section 6 of this report.
- ◆ Several construction considerations were evaluated as part of the study. Constructability considerations for rock tunnels, soft ground tunnels, and shafts in soil and rock were discussed. Methods of excavation, support systems and lining alternatives were evaluated. Site-specific geotechnical information should be obtained and potential groundwater impacts evaluated to further define the recommended construction techniques. Additional information is presented in Section 7 of this report.
- ◆ Impacts from the Fall Creek/White River Tunnel project on the surrounding communities and the environment are of paramount concern. Traffic, noise, light, odor and environmental impacts were considered. A specific environmental impact is the potential influence on the city's drinking water production capabilities and quality. It is critical to protect the city's drinking water supply during the construction and operation of this project. A Phase I Environmental Site Assessment (ESA) was completed. Some of the

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proposed drop shaft sites may have soil and/or groundwater contamination and should be investigated further. Additional information is presented in Section 8 of this report.

- ◆ Risk management considerations during the planning, design and construction of the tunnel system were evaluated. It was concluded that effective risk management and risk reduction would be accomplished through continuous assessment, mitigation and contingency planning. A preliminary risk registry was developed and is included in Section 9 – Risk Management.
- ◆ It was concluded that the geotechnical exploration program should be completed in multiple phases for use during planning and design of the tunnel project. A comprehensive geotechnical exploration program should identify potential geologic hazards, characterize site-specific soil and rock mass and establish baseline ground conditions for the tunnel alignment and shaft locations. Phase 1 components of a geotechnical exploration program were developed and are included in Section 10 – Geotechnical Exploration Program.
- ◆ The Flow Augmentation System consists of the Belmont Advanced Wastewater Treatment (AWT) Effluent Pump Station, Belmont Force Main and Fall Creek Outfall Structure. Evaluations on the proposed pump station, force main alignment alternatives and outfall structures were completed for the flow augmentation and water reuse goals of the project. Additional information on the flow augmentation system components is presented in Sections 11, 12, and 13 of this report.
- ◆ Per the request of the DPW, the Belmont AWT Effluent Pump Station capacity should include 30 million gallons per day (mgd) for flow augmentation needs, and an additional 30 mgd for future water reuse goals. Therefore, the Belmont AWT Effluent Pump Station will be designed for an initial capacity of

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30 mgd with provisions for expansion to an ultimate capacity of 60 mgd. Two possible sites at the Belmont AWT Plant were identified for the Belmont AWT Effluent Pump Station based on input from the DPW.

- ◆ Several force main route alternatives were considered for the Flow Augmentation System. Two alternatives were eliminated from further consideration based on constructability concerns and potential operations and maintenance difficulties. Of the remaining alternatives, Alternatives 4B and 5B were determined to be the most favorable considering cost and non-cost factors.
- ◆ Several types of outfall structures were considered for augmenting flow in Fall Creek. The intent of the outfall structures is to increase dissolved oxygen (DO) levels of the treated effluent prior to discharge into the creek. Constructed wetlands were also evaluated with regards to possible treatment benefits and aesthetic value. Increases in the DO levels were estimated based on limited available data. It was determined that constructed wetlands need a large land area for effective treatment. It was concluded that an outfall structure constructed of large rocks with a small wetland area for aesthetic value was most favorable at this stage in the project. The DPW requested that the Indianapolis Parks Greenways submit a proposal for a constructed wetland area near Keystone Dam, east of Keystone Avenue. This wetland proposal was provided to the project team and is included in Appendix L – Indianapolis Parks Greenways' Recommendation Proposal. Additionally, a more detailed layout of the proposed wetland has been incorporated into Section 13 – Outfall Structures.
- ◆ Several locations along Pogues Run were evaluated for the potential placement of an outfall structure to augment flows in the stream. The intent of the outfall structure is to increase DO levels of the treated effluent prior to discharge into the receiving water. It was concluded that an outfall structure

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constructed of large rocks discharging into the inlet of the constructed wetland and stormwater detention pond near Emerson Avenue and Interstate 70 was most favorable at this stage in the project.

- ◆ Several locations along Pleasant Run were evaluated for the potential placement of an outfall structure to augment flows in the stream. The intent of the outfall structure is to increase DO levels of the treated effluent prior to discharge into the receiving water. It was concluded that an outfall structure constructed of large rocks discharging near Shadeland Avenue and 21st Street was the most favorable alternative at this stage in the project.
- ◆ For the Fall Creek/White River Tunnel, the most favorable alternative based on the cost-benefit was for the West Alignment at 95 percent capture utilizing the Bluff Road working shaft and Sutherland Avenue retrieval shaft. It has a probable project cost of \$674,400,000. This assessment is based on current information and may be subject to change in the future as additional geotechnical studies are completed, and a more comprehensive stakeholder and public outreach program is undertaken. In addition, final negotiations of the CSO LTCP may affect the outcome of this assessment. Additional information on the probable costs is presented in Section 14 of this report.
- ◆ The most favorable alternative based on the cost-benefit assessment for the Flow Augmentation System for Fall Creek, Pogues Run, and Pleasant Run included the Belmont AWT Effluent Pump Station, Belmont Force Main Alternative 4A or 4B, and the Large Rocks with Small Constructed Wetland Area outfall structure. This project has a probable project cost of \$63,800,000. This assessment is based on current information and may be subject to change in the future as additional studies are completed, and a more comprehensive stakeholder and public outreach program is undertaken. In addition, water quality issues, regulatory permitting and goals of the City

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may affect the outcome of this assessment. Additional information on the probable costs is presented in Section 14 of this report.

- ◆ A preliminary project schedule was developed for completion of the Fall Creek/White River Tunnel design and construction. The Fall Creek/White River Tunnel is projected to take approximately 16 years from the commencement of the design phase to construction completion and start-up. The project duration for the Fall Creek/White River Tunnel can be reduced by approximately three years, for a total duration of 13 years, if the main tunnel was constructed in two segments concurrently using two Contractors. To address funding limitations or project goals, the main tunnel could be constructed in two segments with two consecutive construction contracts. Alternate project delivery methods were considered that would reduce the project schedule. However, it was concluded that a traditional design-bid-build approach would likely be utilized for the project and that the tunnel would be constructed in one project phase with one tunneling contractor. Alternate project delivery methods selected by the DPW, project construction phasing, and final negotiations of the CSO LTCP may affect the outcome of this preliminary project schedule. Additional information on the schedule is presented in Section 16 of this report.

- ◆ A preliminary project schedule was developed for completion of the Flow Augmentation System design and construction. The Flow Augmentation System is projected to take approximately seven and a half years. The project duration for the Flow Augmentation System can be reduced by a year, for a total duration of six and a half years, if the Belmont Force Main is constructed in two segments concurrently. Alternative project delivery methods selected by the DPW, project construction phasing and regulatory permitting may affect the outcome of this preliminary project schedule. Additional information on the schedule is presented in Section 16 of this report.

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While available data reviewed for this report provides a good basis for the recommendation of alternatives, additional information is required. This information would be utilized prior to and during future planning, design and construction to adequately manage risk and successfully execute the projects. Recommendations for the Fall Creek/White River Tunnel and Flow Augmentation System projects include:

- ♦ One of the most critical data requirements is the collection of site-specific geologic and hydrogeologic conditions along the main tunnel alignment, connection tunnel alignments, shaft sites (working, intermediate and retrieval) and drop shaft sites. As such, it is recommended that the Phase 1 geotechnical exploration program be conducted during the current planning phase of the project. While there are many data gaps prior to the start of the detailed design of the tunnel and related shafts, the Phase 1 geotechnical exploration program will provide planning level answers and further define subsurface soil, rock, and groundwater characteristics. Data obtained during Phase 1 should provide a better understanding of the existing ground conditions and characteristics. It also would help to determine the most appropriate depth of the tunnel to minimize risk and develop a cost effective design. Completion of Phase 1 in the planning phase also will assist in refining the tunnel alignment; confirming appropriate construction methodologies; identifying the risks that may require mitigation prior to the design; and revising the preliminary opinion of probable construction costs. Additional details on the recommended program are included in Section 10, Geotechnical Exploration Program.

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- ◆ It is recommended that the preliminary sizing of the main tunnel, consolidation sewers, drop shafts, connection tunnels and Deep Tunnel Pump Station be revisited and adjusted, as appropriate, following the completion of the Fall Creek and White River CSO hydraulic modeling.
- ◆ Owners of high capacity wells in the tunnel excavation corridor should be contacted to determine the existing and future capacity requirements as well as the critical nature of the wells during different seasons of the year. Coordination should take place with suppliers of potable water, such as Indianapolis Water, to confirm possible impacts and risks to the groundwater supply upon final selection of the tunnel alignment. Coordination between Indianapolis Water/Veolia Water, DPW, and the tunneling contractors is recommended to protect the city's drinking water during construction. Additional information on groundwater issues related to the project is presented in Sections 3 and 7 of this report.
- ◆ A groundwater monitoring plan should be prepared and implemented to observe and document the effects on the wells, both public and private, prior to, during and after construction of the tunnel. The monitoring plan may include a recommendation for the installation of monitoring wells to confirm groundwater levels, and allow for sampling after construction to confirm that exfiltration from the tunnel is not a concern. Additional information on the groundwater monitoring plan is presented in Section 10 of this report.
- ◆ A land acquisition study should be completed early in the design phase of the project based on the outcome of the Phase 1 geotechnical exploration program and the sampling and analyses of soils and groundwater. If the primary working shaft, intermediate working shaft and retrieval shaft sites are not currently owned by the City, the ability to acquire any property should be evaluated in advance of detailed design.

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- ◆ A power availability assessment should be completed for the proposed primary working shaft and Deep Tunnel Pump Station sites. The tunneling operation and subsequent construction and operation of the Deep Tunnel Pump Station will require significant electricity demand. Additional information is presented in Section 7 of this report.
- ◆ An assessment of flow control and screening options for the consolidation sewers and drop shafts is recommended. Passive, active and real-time flow controls could be implemented at the various sites. The goals of the DPW and operation and maintenance requirements should be included in the evaluation of the flow control and screening options.
- ◆ Computer and physical modeling of the proposed vortex drop shafts are recommended at the proposed depths to confirm the hydraulic characteristics and air movement out of the shafts during simulated tunnel filling events. The physical modeling includes the construction of a scaled model to document actual flow and air movement conditions in the vortex drop shafts. The modeling assessment should include recommendations on design requirements and odor control to treat the exhausting air from the drop shafts.
- ◆ Based on the outcome of the final negotiations of the CSO LTCP, it is recommended that the DPW make a determination of design flexibility for future expansion of the main tunnel. If desired, it is recommended that consideration of land acquisition at future expansion points be included in the early design phase of the project.
- ◆ A risk management assessment and financial bonding capacity evaluation for construction of the Fall Creek/White River Tunnel project should be evaluated at early stages in the design. These evaluations will provide the City with adequate information to minimize project risks before construction begins and

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ensure the recommended project and construction phasing can be financially bonded. Additional information is presented in Section 9 of this report.

- ◆ Flow augmentation and water reuse goals for the project should be evaluated carefully prior to the design. A preliminary design study is recommended to identify discharge points based on stream flows and water quality characteristics. Additional computer modeling of water quality and flow conditions in the streams prior to and with flow augmentation is recommended to simulate conditions under various discharge scenarios. The potential use of a constructed wetland area for additional treatment during flow augmentation should also be examined. This evaluation should include any potential future process and disinfection upgrades at the Belmont AWT Plant.
- ◆ A Phase II ESA is recommended for the shaft sites, connection tunnels, consolidation sewer routes, and the tunnel alignments. Based on information identified during the Phase I ESA, a comprehensive soil and groundwater sampling and analysis program should also be completed. This program would identify potential contamination for risk mitigation purposes prior to design and construction.
- ◆ A Phase I ESA is recommended for the force main routes, and outfall structure locations for Fall Creek, Pagues Run, and Pleasant Run. This program would identify potential contamination for risk mitigation purposes prior to design and construction, and indicate if a Phase II ESA is recommended.
- ◆ Stakeholder involvement, public impact studies and public outreach are critical components in a project of this magnitude. It is recommended that DPW continue developing a long term plan for stakeholder and public participation goals, outreach activities and the creation and distribution of project information during key milestones.

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- ♦ Periodic updates to the opinion of probable costs should be conducted at major milestones and as additional information and data are obtained throughout the planning and design of the Fall Creek/White River Tunnel and Flow Augmentation System projects.